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ORIGINAL PAPER

Environmental Decision Making on Acid Mine Drainage Issues in South Africa: An Argument for the Precautionary Principle

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Abstract This paper examines the issue of acid mine drainage in South Africa and environmental decision making processes that could be taken to mitigate the problem in the context of both conventional risk assessment and the precautionary principle. It is argued that conventional risk assessment protects the status quo and hence cannot be entirely relied upon as an effective tool to resolve environmental problems in the context of South Africa, a developing country with complex environmental health concerns. The complexity of the environmental issues is discussed from historical and political perspectives. An argument is subsequently made that the precautionary principle is an alternative tool, and its adoption can be used to empower local communities. This work, therefore, adds to new knowledge by problematising conventional risk assessment and proposing the framing of the acid mine drainage issues in a complex and contextual scenario of a developing country—South Africa.

Keywords Acid mine drainage · Environmental protection · Ethics · Precautionary principle · South Africa · Water resources

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Introduction

This paper examines the issue of acid mine drainage (AMD) in South Africa and environmental decision making processes that could be taken to mitigate the problem such as the Precautionary Principle. A case against the views that the precautionary principle is non-scientific is presented and the use of this principle in a manner that does not disregard science is demonstrated. The paper begins by giving an overview of the Acid Mine Drainage issue in South Africa and the discussion of the legal and political context on which the management of the issue is based. The challenges of relying on science-based decision-making are then be discussed followed by an argument for the Precautionary Principle (PP). Implications of planning new mines as well as oversight and monitoring of mines are given in the context frameworks provided by previous examples of national and international cases of the PP in practice.

Background to the Acid Mine Drainage Issue in South Africa

Acid mine drainage (AMD) has been in public debate for the past decade in South Africa to the extent of the establishment of an interministerial committee in 2010 to investigate ways of managing the issue. This followed issues regarding the decanting of contaminated water from the old gold mines in an area called Krugersdorp into another area called Cradle of Humankind and the immediate problems arising from gold mining in the Krugersdorp, Roodepoort to Boksburg, Brakpan, Springs and Nigel areas (McCarthy 2011; Naidoo 2014). There are other cases of the AMD challenge such as that of the Grootvlei mine of Pamodzi Gold in Springs where AMD had reached desperate proportions by 8 May 2009. At this point, the then General Manager of the East Rand operations of cash-strapped Pamodzi Gold, was in a situation of possibly being forced to release untreated AMD water on the surface in order to save Grootvlei's underground pumping station from flooding. This would have had far-reaching regional consequences (McCarthy 2011). Environmentalists have, therefore, termed AMD as the most significant threat to South Africa's environment and public health (Simate and Ndlovu 2014).

By definition acid mine drainage has been described as strong acidic wastewater that is rich in high concentrations of dissolved ferrous and non-ferrous metal sulphates and mineral salts, which if left untreated can contaminate ground and surface watercourses, thereby affecting the health of both flora and fauna (Simate and Ndlovu 2014). It is mainly associated with sulphide-rich metalliferous ore deposits such as copper, lead, zinc and gold, as well as coal mines that were formed under marine conditions and contain abundant reactive framboidal pyrite (Sahoo et al. 2013). Acid mine drainage is not only associated with surface and groundwater pollution but is also responsible for degrading soil quality, harming aquatic sediments and fauna and allowing heavy metals to seep into the environment (Adler et al. 2007; Naidoo 2014). A consequence of AMD is that as the water flows out of the mine, it trickles into waterways, permeates the soil and enters the water table,

causing widespread contamination. This is why decisions about this issue are of special significance in environmental and human health protection. Although this subject has been an issue and has received much attention in intellectual debates since the 1970s, to date, there is no commonly agreed strategy of addressing the issue in a way that will satisfy all stakeholders (Sahoo et al. 2013; Simate and Ndlovu 2014).

An interim solution for the toxic tide of acid mine water rising beneath the surface of South Africa's Witwatersrand area was estimated to cost government R145 million (US$10 million), according to claims made by former Water Affairs Minister, Buyelwa Sonjica, while addressing the Agriculture South Africa water conference in the city of Johannesburg (Mining Review Africa 2015). The minister highlighted that the initiative to address the problem revolved around a public–private partnership that would involve government and the mines contributing to the capital costs for the infrastructure needed to pump and treat the water. According to the minister, 70% of mines in South Africa are ownerless, which meant that liability would fall to the state, hence the R145 million (US$10 million). The remaining 30% of mines are owned by private enterprises that would contribute about R73 million to the interim acid mine solution (Mining Weekly 2015).

Every mine in South Africa is unique in terms of its AMD potential and thus, the nature and size of the associated risk and feasibility of mitigation options will vary from site to site. There are no standardised methods for ranking, measuring and reducing the risk of AMD (Naidoo 2014). Considering how large the penalties can be for miscalculating any of the aforementioned variables, the onus is on individual mining companies to take charge regarding this. It must also be noted that the general standards that respond to AMD are to pump the polluted water away to the surface where it can be treated. However, since this is an expensive option, and since pumping is a problem in many unowned mines, the Acid Mine Drainage Plan of SA (Department of Water and Sanitation (DWS), September, 2010) makes provision for pumping water from the mine or decanting the water to lessen the impact of the heavy pollution. In terms of this plan, the underground morphology of the areas was mapped, and areas were identified to which the water could be decanted if pumping stopped. The health risks and effects on the environment were predicted in case the polluted mine water decanted to the surface. In addition, management options were developed to avoid the uncontrolled decanting of polluted mine water to the surface. However, questions arose as to whether or not this amounted to a 'do nothing' option, and the extent to which potentially affected communities were consulted in the process of risk assessment and decision making was also queried.

The Legislative Context

Mineral, water resources and other natural resources have a long and influential historical, and a political angle which needs to be considered in discussions about managing these resources. The current policies relating to the environment are embedded in a continued effort to transition from nearly a century of apartheid rule in South Africa to democracy in 1994. Following the advent of democracy South

Africa's challenges have been based on upholding citizens' constitutional rights to have equal access to water and other natural resources. For example the National Environmental Management Act 1994 (to be discussed later) makes provisions to ameliorate specifically the position of previously disadvantaged persons. Other transitional measures include dealing with the challenges of toxic waste disposal, the environmental costs of unplanned expansion and the need to resolve conflicting priorities about land use. Indeed views about land during the apartheid regime differed from the current period of democracy. Adler et al. (2007) have given a contrast indicating that in the past, land owners who were legally the white minority who owned the water and the mineral resources that lay above and below the surface of their land. In contrast the current constitution makes all natural resources the people's collective property, with government acting as the central custodian.

Furthermore the philosophy behind South African environmental legislation has also been characterised by moving away from colonial authoritarian conservation of imposing values about land on the marginalised. As opposed to the past currently there is a move towards green politics of empowering communities to think about sustainability when interacting with their environment. It is claimed that during apartheid land-use patterns were distorted typified by the blatant use of government policies to favor the mining industry at the expense of the population majority (Adler et al. 2007). This therefore damaged the relationship between people and resources (Ramphele 1991).

Legal and Policy Basis for Dealing with Environmental Damage in South Africa

The strength and advantage of tackling environmental pollution in the South African policy context is that both the issue of environmental protection and that of sustainability are embedded in the constitution. For example Constitution of the Republic of South Africa (1996), provides everyone the right

(a) to an environment that is not harmful to their health or well-(b) to have the environment protected, for the benefit of present generations, through reasonable legislative and other measures (The Constitution of the Republic of South Africa 1996)

As can be seen in the extract above in constitutional terms the AMD issue interferes with people's constitutional right to both a healthful environment and to have the environment protected.

The specific laws relevant to AMD in SA include Mineral and Petroleum Resources Development Act, 2002; the Environment Conservation Act, 1998; the Environmental Management Act, 1998 and the National Water Act 1998. The purpose of the Mineral and Petroleum Resources Development Act, 2002 was mainly to entrench the State's role as owner and custodian of South Africa's mineral wealth by changing the mineral rights system, so that all mineral rights are exclusively State owned and the government has greater authority in the granting of legal rights on mineral and petroleum properties. According to Goolam (2000)

specifically the most significant laws include the National Water Act which is caretaker for protection and pollution by the users. Under this Act an owner of land may be required, rectify a situation on that land which could cause the pollution of a water course (polluter pays) (Goolam 2000).

The National Environmental Management Act promotes co-operative governance between the government departments (The Constitution of the Republic of South Africa 1996). This act has contributed to the major criticism of the South African environmental legislation which has been that it is spread across a broad and complex number of statutes and regulations, at national, provincial and local levels. The issue of this scenario is that the enforcement becomes difficult as many regulatory authorities, tend to have overlapping jurisdictions. In addition to governance and management, under National Environmental Management Act, the Minister is also empowered under it to demand the environmental impact assessments (EIAs) in certain circumstances and this is one of the most relevant legislative basis of the Precautionary Principle (PP).

Having discussed the above the next question that arises is whether there is any legal basis for the adoption of the PP in SA? Indeed South Africa's involvement in international treaties and by virtue of having a democratic constitution, a number of international convention principles are embedded in the statute books. Another important mandate for the PP is that the current constitution also allows stakeholders who include local communities to be given the right to access information and to inform the policymaking process (Adler et al. 2007).

The Challenges of AMD from a Historical Perspective

As has been stated before mining in South Africa cannot be discussed without mentioning its inherent historical and political dimensions that are deeply intertwined with a colonial history of more than a century. In view of the magnitude and potential consequences of the problem of acid mine drainage, these historical and political dimensions as they pertain to AMD in particular must be discussed. With the advent of the new Constitution and legislation reflecting a post-apartheid reality, citizens are entitled to a 'clean and healthy' environment as a fundamental human right (Section 24 of the Bill of Rights) (The Constitution of the Republic of South Africa 1996).

What has prevented these principles from being enforced? Part of the answer lies in the state's continued complicity with mining capital. During the years of segregation and apartheid, the state wilfully ignored the industry's damaging impact on the environment. It is claimed that the apartheid government allowed mining to be privileged, and to maximize profits rendering the sector to be simply an extractive industry that extracted the maximum amount of gold. This resulted in a lowered natural water table and caused much of the groundwater to be exposed to pyrite and other minerals. These impacted on water quality through acidification and heavy metal contamination (Adler et al. 2007).

While part of this analysis focused on the behaviour of the current mine owners, it needs to be made clear that the heaviest responsibility lies with the major mining houses that profited from South African gold and uranium during the boom years.

Key gold mining companies such as the Anglo American Corporation, Gencor, Goldfields and Johannesburg Consolidated Investments were largely transmuted into new legal structures. However, corporate forensics could establish the extent to which they were beneficiaries during their mining operations and make provision for appropriate measures for restitution, which could include addressing the AMD problem where relevant. Clearly, this would require a great deal of political will, which is unlikely to be forthcoming. For example, the state has not supported the efforts by civil society organisations to obtain restitution from the key transnational corporations that benefitted from apartheid. The same reluctance to confront the mining industry still applies. Instead, the state and its taxpayers are likely to be responsible for any remaining bills for mining pollution.

It is, therefore, clear that the government is granting the advantage to the mining houses who pursue the generation of profit vis-à-vis reducing operating costs and the tactical avoidance of liabilities. It is thus critical that government takes decisions that are comprehensive and embrace all concerned. The government cannot continue to ignore the problem.

From the discussion, it can be seen that there is a strong ethical defence for the protection of citizens from the AMD issue. However, several questions arise about the conduct of politicians and all those concerned with the AMD issue:

- What is the approach to risk analysis and risk management that has been used to date in the mining sector (and perhaps condoned in mining legislation in South Africa)?
- Since there appears to be a large measure of scientific uncertainty in determining the further escalation of the AMD problem, what difference, if any, will it make if the PP is applied in risk analysis, risk management and the formulation of future mining policy related to the AMD issue?
- Would participatory, democratic principles make a difference to public decision making regarding responses to the AMD issue?
- Would an application of the PP provide better protection than the current approaches for the poor and the vulnerable who are exposed to current and possible future problems of AMD?

The following discussion seeks to answer these questions. The authors argue that the main issue lies with relying on scientific methods of risk analysis.

Science as a Dominating Decision Making Tool in South Africa

In South Africa, it appears that conventional risk assessment is the preferred modus operandi for resolving the AMD issue. This may be because science is considered as universal (Pick 2001), which means that it has the image of carefully directing the understanding of causal linkages and relationships underlying the connection of policy to environmental protection. Governments in different contexts seek the endorsement of science to legitimise unpopular policy documents since science is perceived as a means to achieve this (Staver 1998). Accordingly, there appears to be

a phobia regarding decisions taken outside of the scientific discourse, as is the case with the PP that is seen as an extremist decision-making tool. No decisions can be rationalised if science has not had an input, despite its inherent uncertainties. Whichever reasons prevail regarding the preference of science in decision making, science is still open to different interpretations by different interests.

Thus, it is necessary to consider the role of science in the proliferation of AMD. Some commentators suggest that science has misled government by underplaying the impact of AMD on human health and the ecosystem. Another interpretation could be that government appropriates the open-ended nature of scientific investigation and scientific uncertainty when it is politically useful (Oreskes 2004). In areas of intense environmental conflict such as AMD (for instance, a political struggle between communities and government or between different interest groups), scientists in general, have little or no influence where policy is concerned. It is, therefore, not surprising that the public has become a great deal more critical in discerning the bias embedded in communications about scientific findings (Conary et al. 1996).

Can Conventional Risk Assessment be an Effective Tool to Resolve Environmental Problems such as AMD?

Politicians and some stakeholders in South Africa tend to depend on science when discussing policy proposals for environment protection. This line of thinking is not surprising because scientific approaches tend to be based on the articulation of two fundamental parameters that are then reduced to an aggregated concept of risk: (a) a list of the factors that may occur: hazards, possibilities or outcomes; (b) an assessment of the likelihood or probability associated with each. Both of these parameters may be subject to incomplete or problematic knowledge. This articulation yields four logical permutations of possible states of incomplete knowledge—of course, these are neither discrete nor mutually exclusive and typically occur together in varying degrees in the real world. Conventionally, risk assessment addresses each of these states by applying the same techniques, that is, quantifying and aggregating different outcomes and multiplying by their respective probabilities to yield a single reductive picture of 'risk' (Stirling 2007).

Specifically, conventional risk management entails the identification, assessment and prioritisation of risk (where "risk" is defined as the probability of a harmful event multiplied by the magnitude of that harm), followed by a coordinated and economical application of resources to minimise, monitor and control the probability and/or impact of unfortunate events. In agreement with its definition, it is clear that conventional risk assessment is a reactive process imbued with uncertainty, hence its challenge to address AMD issues meaningfully and successfully, especially in complex and value-laden contexts such as South Africa (Humby 2013).

In the opinion of the authors of this paper, the mining industry, government and the scientific community must desist from arguing that absolute safety cannot be proved or guaranteed because this could be seen as an excuse and an attempt to hide the

shortcomings inherent in conventional risk assessment. Incomplete knowledge or lack of knowledge regarding the natural systems renders scientifically based, environmental decision making cumbersome. We also argue that surely absolute safety cannot be obtained in this world and certainly not guaranteed. (Beds would be denied to humans because a lot of us die in them). The shortcomings of conventional risk assessment are found in its inability to address uncertainty effectively, which is the hallmark of science-based decision making. As alluded to earlier, it is because science is inherently uncertain that it struggles to deal with the AMD problem.

The uncertainty of conventional risk assessment is mainly driven by a lack of knowledge, which to some extent is influenced by the failure to understand complex natural systems and the uncertainty inherent in science. In addition to the issue of lack of knowledge; it has also to do with the inherent uncertainty in any and all the concepts that constitute our knowledge. These issues cloud the implementation of reliable environmental decision making by shifting the burden of proof from the proponents of an action to the victims of it, as is the case with the AMD issue. The victims of the AMD scourge are expected to prove that mining is responsible for AMD rather than the proponents of the mining activity. This situation is morally incomprehensible and needs to be reviewed by appealing to an alternative decision-making tool such as the PP, which shifts the burden of proof from the victims to the initiator of the project, for example, the mining company.

From the analysis described, it appears that conventional risk assessment tends to rely on only one mode of knowledge—scientific knowledge. Yet, indigenous knowledge and lived experiences are acknowledged in the PP, and such knowledge is articulated by the broader public. We however acknowledge that all (scientific, indigenous etc.) is a variably tested guess at what we think is. We are looking at a scaled variable of reliability for all those concepts we use as our knowledge. In saying so we argue that, indigenous knowledge is typically excluded and not trusted by the scientific community. Indigenous knowledge and lived experiences regarding, for instance, the effects of mining on communities, is typically ignored, which is often confirmed by the lack of participation of communities in the decision making that affects their lives (Failing et al. 2007). The main drivers of these processes are scientists who possess authority for the final decisions despite objections raised by communities (Reed 2008). The decisions of the scientific community will subsequently be approved by bureaucrats who regard them as trustworthy servants. A scenario in which the non-scientific community may assist scientific communities and policy makers in the decision making for resolving the AMD issue by articulating indigenous knowledge and lived experiences is lacking in this context. Unfortunately, this exclusion of non-scientific communities has led to a mistrust of science, whilst the victims are left to bear the consequences of the AMD mismanagement.

Although taking dominance in environmental decision making, conventional risk assessment has its inherent weaknesses, notably in regard to uncertainty, and in most cases, it fails to understand the complexities inherent in social and environmental systems (Carolan 2007). Thus, it is a monocratic decision-making tool that borders on autocracy because it makes decisions without embracing and articulating community concerns (Carolan 2007). It is the conviction of the authors

of this paper that conventional risk assessment protects the status quo, is unreliable and in an unjust manner, shifts the burden of proof away from the proponents of an action to the victims of it. Thus, it is argued that conventional risk assessment is flawed, and it cannot be relied upon as an effective tool to resolve environmental problems such as AMD.

Therefore, to overcome the barriers of science-based, decision-making tools, it is critical that one advocates for a decision-making and action tool with ethical power and scientific rigour such as the PP, which has become a crucial aspect of environmental agreements and environmental activism throughout the world. The question we therefore ask is: does such ethical power and scientific rigour not make the PP scientific? As the PP deals in caution and prudence in progressing proposed projects it uses the most reliable components of our current knowledge base with all its uncertainties as a means of coming to a conclusion as to how to proceed. But note; if we are to apply the stipulations of the PP to the use of the PP we may arrive at an unsolvable quandary. Despite this aforesaid concern we advance the argument that PP offers the public and decision makers a forceful, common-sense approach to environmental and public health problems. Other considerations in argument for the PP include problems regarding burden of scientific proof, scientific uncertainty and the complexity of our environmental systems. In most cases, these problems result in the taking of actions to prevent harm only after significant proof of harm is established, at which point it may be too late. These issues are discussed in the defence for the PP.

The Way Forward with AMD: Precaution-Based Approaches to Environmental Decision Making

According to Gonçalves (2006), critics of using the notion of precaution in environmental decision making often emphasise the concept's vagueness and ambiguity. However, this criticism is usually directed at a specific formulation of the PP rather than the process-based precautionary approach to decision making that will subsequently be described. Critics of approaches to decision making that are based around the notion of precaution often acknowledge science/risk-based assessment approaches as being the preferred alternative (Vermeule 2012). The claim that regulation should be science/risk-based as opposed to precaution/uncertainty-based appeals to the traditional image of science providing certain and objective knowledge, revealing the real world as it exists outside of social and cultural frameworks. The presentation of precaution and science-based approaches as representing mutually exclusive decision-making strategies serves to suggest that precaution-based approaches result in decisions that are not based on a rigorous assessment of evidence (Stirling 2007). However, there are views that do not support this assertion regarding the PP and, therefore, the provocative statement, 'the PP is scientific', is advanced.

A constructivist understanding of scientific knowledge suggests that the facts (statements of the nature of what we take as reality) are always influenced by social factors and subjective framing assumptions (Carolan 2007; McCall 2000). Since a

precaution-based approach accepts this and attempts to provide a process for dealing with the various types of incertitude involved in environmental decision making, this approach is usually favoured by those adopting constructivist positions on the nature of scientific knowledge.

It has also been argued that science-based and precaution-based approaches to environmental decision making do not have to be conceptually separated. In fact, one type of precautionary approach can have a more authentic claim to the meaning of 'science-based' than the traditional, narrowly framed approaches to risk analysis (Carolan 2007; Stirling and Gee 2002). The argument in this case is that denying the existence or relevance of the challenges associated with uncertainty and ignorance in decisions involving the prediction of impacts in complex, interacting and open-ended systems does not in effect represent a rational approach to decision making. In this regard, it is suggested that a precautionary approach's greater attention to diversity of knowledge could be considered more scientifically robust than the relatively narrow and uncertainty suppressing tendencies of so-called science-based approaches. Examples of such approaches are cost benefit analysis and risk assessment (Stirling and Gee 2002). This argument therefore leads to the need to review arguments about definitions of precaution that honour scientific approaches.

A Definition that Honours Scientific Approaches?

In discussing the synergies between PP and science Todt and Luján (2014) argue that even though the specific role of science varies from one version of precaution to another there is a possibility of invoking definitions that do not marginalize scientific knowledge in decision making. They also acknowledge that at times precautionary regulation may, in strict circumstances truncate innovation and that precautionary decision making in particular cases can be shaped exclusively by extra-scientific factors (Todt and Luján 2014). According to Gray and Bewers (1996) such extra-scientific factors need not to be unsubstantiated perceptions of effects or gut feelings that something has an effect but rather scientific evidence should be the basis. In this regard Morton and Routledge (2016) offer an example of moving away from being guided by extra-scientific factors by indicating that one pitfall is determining what constitutes sufficient evidence of risk to serious harm as provided in most guiding documents on the PP. They give a list of such examples of instances that can constitute minimum risk. These include evidence of damage having occurred in other similar circumstances; early warning signs of threats; and evidence from controlled experiments for a causal mechanism of such impacts (Morton and Routledge 2016). Viewed in this way it can be seen that the PP has a synergy with the scientific method.

Definitions that Offer a Model for the South African Context

Previous applications of the Precautionary Principle especially in the North sea have tended to consider damage in terms of specific chemicals. However, other scholars (Gray and Bewers 1996) have argued that damage should not be limited to specific chemical elements but even physical damage. This is relevant in South Africa where

environmental damage to land by mining is not just chemical contamination but in indigenous frameworks. This includes how land can be defaced and how the natural state of water can be altered in the case of AMD.

Another issue with the North Sea definition and application of the PP has been the tendency to be specific about aspects or scientifically defined territories of the environment. In this instance the model used in North Sea and seen as one way of drawing the definition of PP towards being scientific by employing specificity in terms of territories e.g. 'habitat' not 'ecosystem' because habitats have clear boundaries in coastal areas in contrast, ecosystems have no clear properties. Gray and Brewers, have however argued that it is, impractical to have a series of definitions of the Principle that apply individually to only one aspect of environmental damage and conceptually differing definitions for different compartments of the global environment. They therefore define the PP in a manner that permits the application of the PP by means which may not point to scientifically defined territories of the environment 'habitats'. Such a generic approach may be usefully empowering to indigenous communities who are holistic in their view of the environment. This will indeed disempower indigenous people who are major stakeholders in the post-Apartheid South Africa.

The Trajectory of the Synergy Between Science and Precaution-Based Approaches

As has been argued before the process of using risk analysis to make decisions has traditionally been based on a belief in the certainty and objectivity of scientific knowledge (Dixon and Oyebode 2007). The challenges associated with applying this approach to decision making, for example, in determining the environmental impact of new technologies, have largely been made visible through the conceptualisation of new and different types of incertitude that are involved in these types of decisions (Glanz et al. 2008). Wickson (2005) argues that these challenges require a new approach to decision making that is better able to acknowledge and manage the full range of types of incertitude. Such an approach must recognise the limitations of scientific knowledge, engage the public and the different stakeholders in decision deliberations, assess a range of different policy options and focus on the fostering of diversity, resilience, flexibility and adaptability. This approach has been characterised as precautionary rather than science-based. Distinguishing between science- and precaution-based approaches to decision making does not imply that approaches using scientific information cannot involve the adoption of a position of caution or that precautionary approaches do not involve the use of scientific knowledge or experts. Rather, the role and the degree of influence awarded to scientific knowledge and expertise are distinguished. In science- or risk-based approaches to decision making, science has traditionally held a plurality of rationalities and value sets and a broader range of concerns that allow it to express monopoly on authority. In precaution-based approaches, science is recognised as having limitations, and this enables a plurality of rationalities and value sets and a broader range of concerns to be recognised and embraced in the decision-making process.

The PP and Scientific Uncertainty

The PP determines that scientific uncertainty about the causal relationship between an activity or product and harm to the environment (serious or irreversible) shall not be a reason for postponing action to protect the environment (Lempert and Collins 2007). Thus, in the case of scientific uncertainty and risk of significant harm to the environment, the PP requires the taking of measures to protect. Such measures could include transparent environmental/risk assessment procedures combined with participative community decision-making processes and on the basis of this, all relevant factors could be considered and concerned individuals and groups could participate in decision making (Stirling 2007). This could also be the case in the implementation of a new "whatsit". Such an introduction into use would proceed with caution and under control. Prudence and care are the operative words to condition such a new introduction.

The combination of threat of harm and scientific uncertainty determines the application of the PP. For example, certain people may state that the threatened harm or hypothetical harm must be serious or at least irreversible, whilst others may point out that this does not necessarily allow for the cumulative effects of a large number of relatively small risks (Lempert and Collins 2007). The PP moves from the position of asking how much damage or harm is tolerable (typical of the conventional risk-based approach) to determining how to reduce or eliminate hazards and considering all possible means for achieving that goal, including cancelling the proposed risky project or activity (Carolan 2007; Stirling 2007). According to the PP approach, it is also critical, to seek alternatives for a hazardous activity or project, and such alternatives must be subjected to gruelling scrutiny. In this case, the PP can help science to deal with uncertainty by providing a tool that recognises uncertainty and indicates a strategy to respond to it.

An important suggestion by Gray and Bewers (1996) on the issue of Environmental Impact Assessments (EIAs) involve scientific predictions. This is a scenario whereby if predictions are wrong, there is seldom a penalty for those who made the incorrect predictions. They argue that penalties on those who make wrong predictions can be one way ensuring that uncertainties give the benefit of the doubt to the environment rather than the discharger/disturber. This model can be adopted in SA where scientist have at times been accused of bias or colluding with the government or miners when doing EIAs (Adler et al. 2007).

The PP and Shifting the Burden of Proof

As mentioned previously, the PP states that if an action or policy has a suspected risk of causing harm to the public or to the environment and the scientific consensus that the action or policy is not harmful is absent, the burden of proof that it is not harmful falls on those carrying out the action (Peel 2005). The PP assumes that the proponents of a product or project should provide evidence that: (a) they have examined all reasonable alternatives and are conducting their business in the least

harmful way possible; and (b) their activities are not likely to degrade human health or the natural environment. For example, in the case of environmental decision making involving mining, the proponents of mining should be able to demonstrate that their actions or policies are not harmful (Peterson 2006; Renn 2007).

The PP, therefore, takes a clear and unambiguous position. Policy makers must justify discretionary decisions in situations where there is the possibility of causing harm when making a certain decision, for example, taking a particular course of action, when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm when scientific investigation has found a plausible risk (Peel 2005). This protection can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result (Lempert and Collins 2007).

In other words, mining houses, government and scientists have a moral obligation to demonstrate that the envisaged environmental project will not result in irreversible damages that outweigh the benefits. In this equation "outweigh" is important to consider for example in the invention of a car. Otherwise we would not have the car which kills some 1,300,000 people per year in the world if we applied the PP to it in the year 1900. The important thing is that the responsibility to prevent harm lies with the initiator of the mining project and the decision makers. The burden cannot be shifted to the victims of the environmental onslaught to prove otherwise. The PP clearly states that those who have an interest in the endeavour should not allow collateral damage to ensue on afflicted communities. Those who initiate a project, mining or otherwise, should be placed under a strict obligation to present a persuasive case for what they wish to do and must accept all the consequences that arise due to the project. Burden sharing includes an obligation on the part of those who initiate and are involved in the mining projects. With regard to shifting the burden of proof in a mining context, the proponents of the activity have an obligation to ensure that at the end of its lifetime, the decommissioning of a mine will not result in AMD. Formulated in more detail, the proponents of mining or the mining industry have an obligation to test the ground for possible AMD causation and to communicate such information publicly without distortion (Reed 2008). Furthermore, the PP acknowledges that communities and people affected by mining have the right to know the details of the project since they are the ones who will be negatively affected should situations go awry. This is a right enshrined in the Bill of Rights of the Constitution of the Republic of South Africa, and the PP is clearly a viable decision-making tool that can give effect to this right (Humby 2013). The communities also have the corresponding obligations to give a fair assessment of activities given to them for consideration.

The PP and Indigenous Communities

The promise of the PP is highlighted by its capacity for public participation in environmental decision making. The PP has demonstrated its common approach by pointing out the marginalisation of communities in decision making due to subjecting indigenous knowledge to the periphery. Often communities are not considered regarding matters that affect them and their environment (Green 2012).

The PP demonstrates that decisions that are taken outside the realm of democracy are likely to rebound with grim consequences. The PP insists on retrospection and reflection by calling for common sense. It includes participatory democracy wherein the views of the affected communities are taken into consideration, thereby avoiding such carnage as unfolded in certain parts of the country in the South African mining protests (Green 2012). The PP thus calls for termination of environmental degradation by appealing to the common-sense approach, which includes democratisation of decision making and recognition of indigenous knowledge (Failing et al. 2007). The approach argues that certain failures in finding lasting solutions to the scourge of AMD can best be addressed by articulation of indigenous knowledge in the mainstream scientific discourse. Given this, the PP is positioned to address the gaps created by the politics of exclusion that undermine public confidence, particularly where public concerns are not taken into consideration (Mercer et al. 2007). In other words, the PP states all are equal before the law notwithstanding their social standings.

The PP plays an important role in terms of when to take protective and preventative action. As such, the PP entails a duty of care that is closely related to the duties of good neighbourliness and due diligence emanating from sources such as Roman law. This correlates with relations between neighbours, the duty of reasonable and equitable use and the obligation to refrain from abuse of rights. The duty of care enjoins policy makers to take proactive action in situations where the risk of endangering the environment or human health is high. The duty of care as articulated in the PP can be reinforced by scientific knowledge about the environment in question and the availability of technology that is able to protect the environment and its citizens.

As such, the PP encourages that the more that is known about the vulnerability of an ecosystem and how to protect it against degradation together with the increased availability of technology to protect the ecosystems or sensitive sites, the more concrete are the preventive measures required. As has been stated earlier on, in the case of mining in South Africa that has contributed to the scourge of AMD, the government has a constitutional duty of care to take appropriate and timely action to protect the environment. This includes protecting the public from harm that can be reasonably foreseen to follow from mining activities, even if causal links between the envisaged mining activities and their possible effects are not scientifically proven. In cases where harm has been demonstrated by lived experiences to be clear and present in communities and the environment, as is the case with AMD, the duty to address this harm is even more apparent.

As previously argued, it has become clear that mining houses must demonstrate a duty of care as propagated by the PP, thereby ensuring that mining projects or other environmentally related projects do not hinder the valuable ecosystems upon which communities depend. This can be achieved by ensuring that ‘no-go’ areas are established where mining will not be allowed if it is proved that the mining activity may result in harm to the ecosystem and the surrounding communities. In other words, financial considerations should not be in the forefront when such decisions are taken. Instead, the driving motivation should be that of protecting and

safeguarding the environment and the health of the people while at the same time deriving benefit from the natural resources that are at hand.

Local and International Models: The PP in Action

To date the most revealing application of the PP in the context of mining in Sub-Saharan Africa has been that of an EIA that conducted on the Eastern Shores of Lake St Lucia north of the Province called KwaZulu-Natal (Kruger et al. 1997). This case of application of the PP was significant in three senses. Firstly; it provided an instance where lay stakeholder opposition to the mining resulted in abandoning of mining; secondly; participation in the EIA happened at a time when the social values widely differed in South Africa-during the apartheid era. Regardless to the colonial bias towards mining the voices of the marginalised were heard. The third reason related to the acknowledgement of complex immeasurable ways of viewing land damage which was called 'intangibles' or 'the sense of the place' (Kruger et al. 1997). This is indeed a model to be adopted in South Africa as indigenous ways of considering damage to the land may not always be measurable.

Another lesson learnt from international examples is that of the former Justice Bruce Cohen of the British Colombia Supreme Court that salmon farms "cease operations" in the Discovery Islands as a precautionary measure to reduce risk of serious harm to Fraser River Sockeye Salmon. In this instance it was recommended that if salmon farms cause greater than minimal risk of serious harm they should be banned by 2020 and a clear definition of minimal was given as a proportion determined by scientific means (Morton and Routledge 2016). One of the major features of this example is that the commission's recommendation took into account the relative cost of proposed precautionary measures against possible losses due to the perceived threat (Morton and Routledge 2016). Such an example would be useful in South Africa where the new Mineral and Petroleum Resources act 2008, previously discussed, provides for the need for mineral resources to benefit local communities economically.

While the above instance shows an example of a halt after consultation there are examples internationally where ministerial powers have been used to invoke precautionary measures before the EIA similar processes. For example the case of Lake Pontchartrain, Louisiana in the United States (Kaszuba 2002). In this instance local crabbers, and non-profit groups, contested the continuation of dredging on the grounds of degradation of the ecosystem. In this state the Louisiana Department of Environmental Quality (DEQ) denied water discharge permits for dredge companies. Although the companies challenged the move the courts upheld the claims of local stakeholders citing confirmation of damage through subsequent ecological studies (Kaszuba 2002). The important lesson learned is that despite the uncertainty over exactly where and how much damage could be expected, the precautionary approach was taken to err on the side of protecting the environment and human health. This example may not offer a stronger comparison with South Africa as it involved wealthy local communities which may not be the case in South Africa.

Implications

In general, the PP advocates proactive considerations to be adopted by drawing community members to partner with government and scientists in finding a lasting solution to the problem of AMD. It is acknowledged that currently in SA, there are indeed partnerships between government and communities that are being forged with a view to addressing the challenge of AMD, particularly in the Western Basin in areas such as Carolina and certain parts of Gauteng (Humby 2013). However more could be done and the following are implications that point to bottom-up proactive procedures that are based on the PP.

Planning a New Mine

If a new mine is envisaged, the PP strongly argues that such a mine should be subject to stringent environmental laws and in SA this is by way of transparent prospecting licensing. Initially, the PP requires that before any course of action is taken for the mining activity, all role players should be effectively consulted and incorporated into the decision-making process to ensure that all concerns are addressed, as was seen in the case of St Lucia discussed earlier. This should be irregardless of whether stakeholders have 'only' lived experience and non-scientific knowledge or scientific knowledge. In addition, notice of prospecting should be advertised in local newspapers using the predominant languages of the area in question. The PP also instructs that before any prospecting can be allowed, feasibility studies must be undertaken by way of conducting environmental impact assessments (EIAs). These should be adjudicated by non-scientific communities with their elected environmental scientists together with the scientists representing government through the scoping process of the EIA. In the final EIA report, all concerns raised by communities and other interested and affected parties should be reflected, particularly where there is suspicion of potential hazard to the environment and to the parties affected by the proposed mining project.

Additionally, the PP dictates that those who have an interest in the development of the mine and those who may be affected by the impact of the environmental project should have the right and the power to influence the acceptance or rejection of the status quo if signs of environmental degradation begin to emerge. In Morton and Routledge's (2016) model such signs of degradation should be in terms that can be more than just anxiety of potential risk. However, subsequent to commencement of any mining activities, the PP requires that all information regarding environmental impact emerging from conventional EIAs or climate risk assessments (CRAs) must be made available publicly. This is to enable communities and people that could be adversely affected to have such information validated and assessed by experts chosen by them. By following this approach, decision makers will avoid the objection of bias, the ignoring of affected communities and/or unilateral progression. The PP also requires that EIA or CRA reports be communicated to the public

in non-technical terms and in the language that is best understood by those affected by the decision that is envisaged.

On a technical level, the PP enjoins the actors or initiators of a mining project to conduct, as part of their EIAs and quantitative risk assessments (QRAs), pre-mining sampling and analyses for acid-producing minerals, based on acceptable practices.[1] For the purposes of transparency and effective community participation as required by the PP, the typical practice of keeping sensitive information regarding the possible or actual harm that may occur on particular sites away from the public domain should be regarded as anathematic, irresponsible and unethical. In fact, sensitive information regarding mining sites and operations should be declassified and published to enable any affected role players to present their input through their appointed experts.

In terms of identifying sites for mining development, the PP similarly requires that it is the responsibility of the proponent to indicate to the relevant government departments that the operations of the mine will not initiate risks to the environment or to the surrounding communities.

Oversight and Monitoring

Given the unavoidable uncertainties inherent in science, it is a reality that if science-induced projects are not monitored through processes beyond science, they are likely to deliver results that may have negative unintended consequences as by-products. In this regard, the PP imposes a duty of care on policy makers and the mining industry alike to make sure that natural ecosystems and communities are not adversely affected by the activities that they respectively have licensed or embarked upon. In practical terms, this entails not only effective oversight by the board members and regulators of companies influencing the environment but also detailed and meticulous monitoring of routine activities, with effective community involvement in all of these processes. Further, in cases where violations occur, the duty of care required by the PP dictates that owners, that is, mining houses in the case of AMD, should immediately take steps to prevent the challenge becoming out of control.

In order to ensure that these aspects of the ethics of care are properly and effectively executed, the PP requires that the environmental performance of mining houses be audited by a team of highly trained specialists and that their findings be addressed in independent environmental audits. These audits should be conducted regularly and as indicated previously, peer reviewed by affected communities through their chosen experts, and the results must be communicated and made available. As such, the PP states that communities, through their elected leadership, should have the right to independent monitoring and oversight of the environmental programme, thus considering the lived experiences of the involved communities

[1] Of course, this type of sampling and analysis should be done in all cases of mining activities already in operation.

regarding their health together with the lay and/or indigenous knowledge of the environment.

Conclusion

Despite the criticism levelled against the PP as being anti-scientific, the PP represents a challenge to scientists and policy makers to develop newer and more effective tools for characterising and preventing complex risks and to be more explicit about uncertainties. The authors of this paper, therefore, conclude that the PP is not in disagreement with conventional science but rather complements evidence-based practices in situations of scientific uncertainty and complex risks. Furthermore, the PP may be seen as consistent with good science and good public policy because it acknowledges the inherent uncertainty and limitations in our understanding of complex risk challenges. Therefore, the PP enjoins policy makers, scientists, members of the community, and others to develop new methods and tools to characterise these threats and focus attention on opportunities for prevention and innovation.

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